LAB 1

GRAVITY AND MAGNETIC DRIFT CORRECTIONS

Transfer absolute gravity to the base station(s). To do this, find the difference in mgal between where you know absolute gravity (in our case the seismic vault) and the base station. The UofS absolute gravity station is 981.108375 gal. The instrument is drifting during the transfer process, so you need to take this into account. There are two approaches. Plot all of the vault readings and all of the base readings vs time, drift correct them (use the same drift curve for both) and estimate the offset. Or, find the difference between each vault reading and the nearest base reading in time, and average all these. Don't forget that the dial readings need to be converted to mgal. From the table, the factor for this interval is 1.04845.

Calibrate your gravity data. The Lacoste instrument is a relative reading gravimeter, so the dial readings you recorded need to be converted to calibrated readings in mgal. As it happens, the calibration constant is nearly 1, so the dial reading is almost in mgal anyway. The calibration table for this instrument (G267) is attached.

Drift corrections are necessary for both gravity data and magnetic data. With gravity data, the instrument itself may drift and there is a regular and predictable variation in the field due to the earth tide. Our gravity meter has a very well behaved drift, so most of the time variations are due to the earth tide. The magnetometer has no intrinsic drift, but there is a large and mostly unpredictable drift of the field itself.

To correct gravity or mag using a base station you must first select a base or reference level. A good choice would be the instrument reading at the base station taken just before the field collection commenced. Later, the reference level is subtracted from all base and all field readings, so that the base readings are all zero (or fluctuate about zero with a small standard deviation). Then, absolute gravity at the base station is added to all base and field readings, so that the survey is now on an absolute scale. Gravity meters typically have a high initial drift after being put into use following a long period without power, so it is usual to give this initial drift time to settle down before starting the survey. It is also good practice to monitor the drift by taking a series of base station readings before the field survey commences and at the start of each day, and possibly at each crew change. The principal of the drift correction is that if a base station reading is higher than the base level at some previous time, then the instrument is reading high at that later time, or gravity (in a large area including the whole survey area) is high at this time. Base station readings must therefore be taken frequently enough to properly characterize the drift. How frequent base station occupations need to be depends on experience, the particular instrument in use, and local and current conditions.

Our Lacoste has a very low intrinsic drift, and the tide is so predictable, it is best to subtract a prediction of the tide from all base station and field station readings, and then do a drift correction as described above and below (this will then be all instrumental drift). If the instrument and operators were performing well, you should see an instrument drift that is almost uniform over the several days data were collected.

1) Plot base station readings vs time. Most of the variation you see should be the tide. Using the matlab m-file TIDES, calculate the predicted gravity tide for the area of your survey. (Do help TIDES to see how this works. TIDES can also calculate a running time for you, which you will need for the drift correction). Plot the tide corrected base station readings as a function of time. This should be almost all instrumental drift. You should be able to draw a fairly smooth curve through all the data. If you cannot, this is a warning that something is wrong. Has the drift changed character during the survey,

or is there any evidence for tares?

2) Define a drift curve (on which you can interpolate to the times of your field readings) for each segment of data, that is each day, or each set of data collected by one person on one day. Each of these drift curve segments should look similar, and similar to a smooth curve drawn through all the data. If not, there may have been an instrument problem, such as a tare. Since the instrument can be read to only $\pm 0.01mgal$ your drift curve is a compromise between smoothness (if the drift is not smooth the drift correction will be unreliable) and honoring the base station readings to about the $\pm 0.01mgal$ level. It is convenient to define the drift curve such that subtracting the drift curve from base observation results in a zero mean for the corrected base observations.

3) As a test, you should use your drift curves to 'drift correct' the base station readings. The corrected base station readings should have a mean equal to the selected base level (this is arbitrary, but again, zero is convenient), and a standard deviation about this level of about $\pm .01mgal$. There should be no extreme outliers greater than say $\pm 0.02mgal$. If there are, you need to trace the problem back through the data. You could redraw the drift curve so it was less smooth, but if the cause of the outliers is a recording error in the observers notebook, then this error will be propagated into the field observations taken around the time of this base station reading. A smooth drift curve will not propagate such an error. The accuracy and reliability of your drift corrected field data depend on the accuracy and reliability of your drift curves, because you interpolate a drift correction for field data from these curves. Any error in the drift curve is propagated into your field data.

The mag drift is less problematical because the instrument itself has no drift, unless it is malfunctioning, and time variations in the field itself are usually small. The field instrument and base station instrument communicate with each other at the end of the day and a drift correction is automatically performed. Here is how it is done:

$$\begin{aligned}\text{CORRECTED} &= (\text{UNCORRECTED} - \text{DATUM}) - (\text{BASE} - \text{REFERENCE}) \\ &= (\text{UNCORRECTED} - 57000) - (\text{BASE} - 57000) \\ &= (\text{UNCORRECTED} - \text{BASE})\end{aligned}$$

Since UNCORRECTED and BASE are going to be similar, this means that all of your (corrected) readings will be about 0. This is because of the choice of DATUM and REFERENCE. The true field readings are not available from the corrected data, and if you need them, you would have to go back to the original data file downloaded from the OMNI. Adding about 59000 Nt would be close. As long as the base is set up in the same place each day, and the equipment is working well, the above will result in a good drift correction.

A repeat is a second or third etc observation at one of the field stations. These are used to assess the overall *repeatability* (not accuracy) of the survey. Since the major problems with repeatability arise from the uncertainty of the drift correction, the precision with which a single observer can re-read the instrument, and the biases between different observers, a proper repeat is one performed by a different operator, at a very different time in the survey. It is good practice to perform at least twenty percent repeats, and for best results the entire survey may sometimes be repeated.

The repeats may also be used as a check on the drift curve. In other words, is the difference between an observation and its repeat consistent with drift that occurred between these two times? In some cases, for example where it is logistically difficult to establish a base station that can be returned to quickly from any station in the survey it is possible to construct a drift curve from the repeat readings, although this is not recommended. If a tare has occurred in the interval between two base station readings, repeats performed during this interval may be useful in narrowing down the exact time of the tare, and in identifying which stations need to be done again.

4) Calculate

$$\sqrt{\frac{\sum \text{REPEATS}^2}{\text{NO of REPEATS}}}$$

Where REPEAT is the difference between a station observation and its repeated observation, both drift corrected. Do this calculation for both gravity and mag. **This is a very important number - it tells you how reliable your data are.** Any feature in the data this size or smaller is unreliable. Any correction, or the uncertainty in any correction this size or smaller is not important. For example, the horizontal station location N-S need only be known to $\pm a \times 12m$ if your repeats are only good to $\pm a \times 0.01 mgal$. The required precision in the vertical position of each station, and the required precision in the terrain density are also controlled by this number.

5) Make a table for gravity reductions
LAT, LONG, HEIGHT, DIAL, CALIBR, TIDE, TIDE CRCTD, DRIFT, DRIFT CRCTD, ABS

6) Save a new copy of the data in a Matlab .mat file for use in subsequent labs

CONVERTING DIAL READINGS TO CALIBRATED GRAVITY

1) read the counter eg 4654.3
2) read the dial 4654.36
3) using the table obtain the value in mgals for the reading in the table which is nearest this value but less than it (ie 4600 gives 4817.47)
4) obtain the difference in counter reading ie 54.36
5) multiply this by the interval factor 1.04845
6) add 4817.47+1.04845 x 54.36=4874.46 calibrated value

PART OF G267 CALIBRATION TABLE

COUNTER READING	VALUE IN MILLIGAL	FACTOR FOR INTERVAL
4300	4502.91	1.04853
4400	4607.77	1.04853
4500	4712.62	1.04848
4600	4817.47	1.04845
4700	4922.31	1.04844
4800	5027.16	1.04855
4900	5132.01	1.04855

LaCoste, L. 1991. A new calibration method for gravity meters, Geophys. **56,** # 5 701-704.

LaCoste, L. 1991. Gravity meter calibration at LaCoste and Romberg, Geophysics, **56,** # 5 705-711.